INTRODUCTION

Every year the Pacific stock of humpback whales migrates to Hawaii to breed between December and May although individual whales can be seen as early as September and as late as June (Craig and Herman, 1997). Pregnant females are the first to arrive in Hawaii followed by sexually mature males. Some whales may remain on the feeding grounds all winter or not make a complete migration (Craig and Herman, 1997). The breeding grounds lie mainly between the shoreline and waters up to 100 m deep and mothers seem to especially prefer shallow waters to give birth and nurse their young. Currently, the humpback whale population in the Hawaiian wintering grounds is estimated at 5,000 whales. For the past few years the Hawaiian Islands humpback whale population has been increasing at a rate of approximately 7% (Mobley *et al.*, 1999; Mobley *et al.*, 2001).

While whales are distributed throughout the main Hawaiian Islands archipelago in the winter, higher concentrations have been identified in the shallow waters between Maui, Lanai, and Molokai; near Penguin Banks, a shallow water embankment between Molokai and Oahu; and around the Island of Hawaii (Mobley *et al.*, 1999; Mobley *et al.*, 2001, Maldini 2003). Patterns of distribution appear to change throughout the breeding season and on a yearly basis.

Although localized studies have been conducted for decades, and regular aerial censuses are conducted yearly to monitor whale abundance and distribution, gaps in knowledge on preferred habitat use and the factors influencing distribution patterns on a larger scale still exist. The annual Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) Ocean Count is a coordinated shore-based census of humpback whales conducted on four of the main Hawaiian Islands at the same time each year. The census provides a simultaneous look at the patterns of distribution and abundance close to shore to identify hot spots of abundance around the islands of Oahu, Kauai and Hawaii, and at one location in Kahoolawe and the persistence of these hot spots as preferred areas over the years.

Results from this study will inform future management decisions about sanctuary boundaries and restrictions during times of heavy humpback whale use. The general trends in whale behavior at each site may provide an insight on the use patterns of a particular area, when looked at over a period of several years. For example, a site where mothers spend a lot of time socializing with other whales or interacting with their calf

will have a higher frequency of aerial and social behaviors than an area where whales just pass through. Trends over years of observation using a consistent methodology may provide a gauge of the importance of a particular site to humpback whales.

STUDY AREA

The study area includes waters from the shoreline to a variable distance offshore around the islands of Oahu, Hawaii, Kauai and Kahoolawe. The census was conducted at 25 sites on Oahu (Figure 1), 15 sites on Kauai (Figure 2), 22 sites on Hawaii (Figure 3) and one site on Kahoolawe (Figure 4). Site location was kept consistent over the years to provide comparative data.

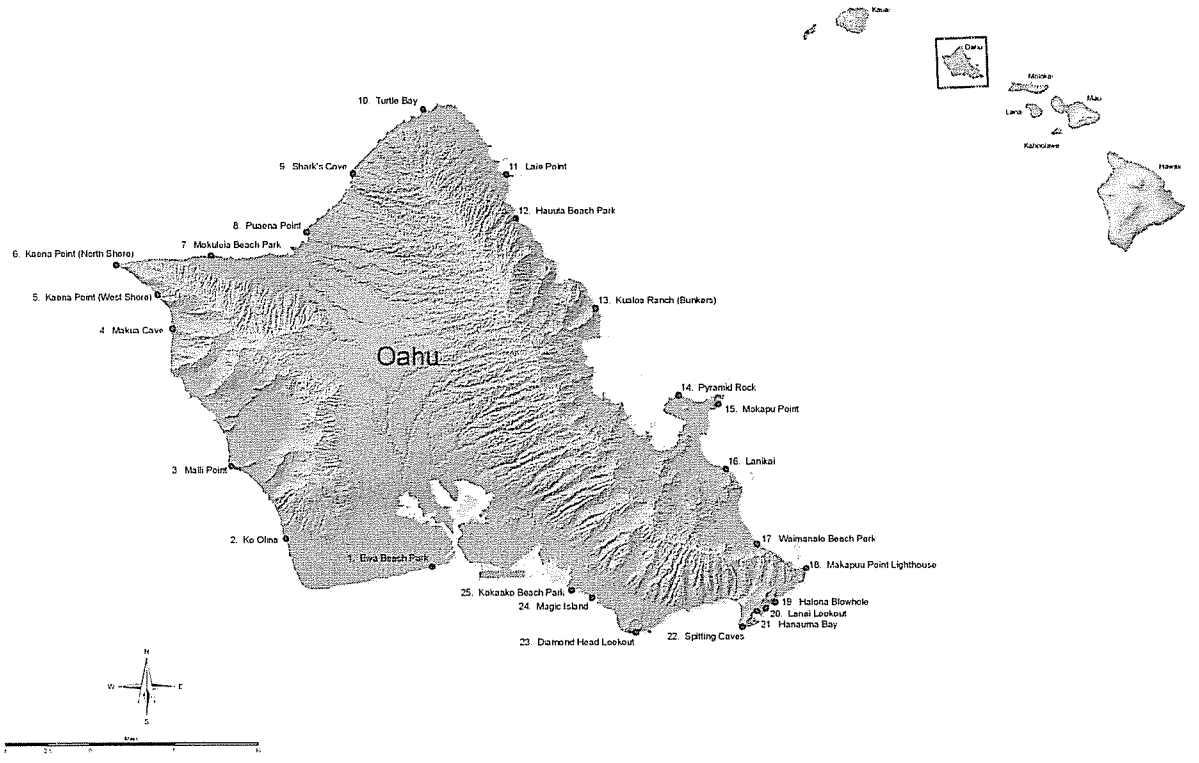

Figure 1 — Island of Oahu: location of the 25 shore-based sites where the humpback whale census was conducted between 2002 and 2005

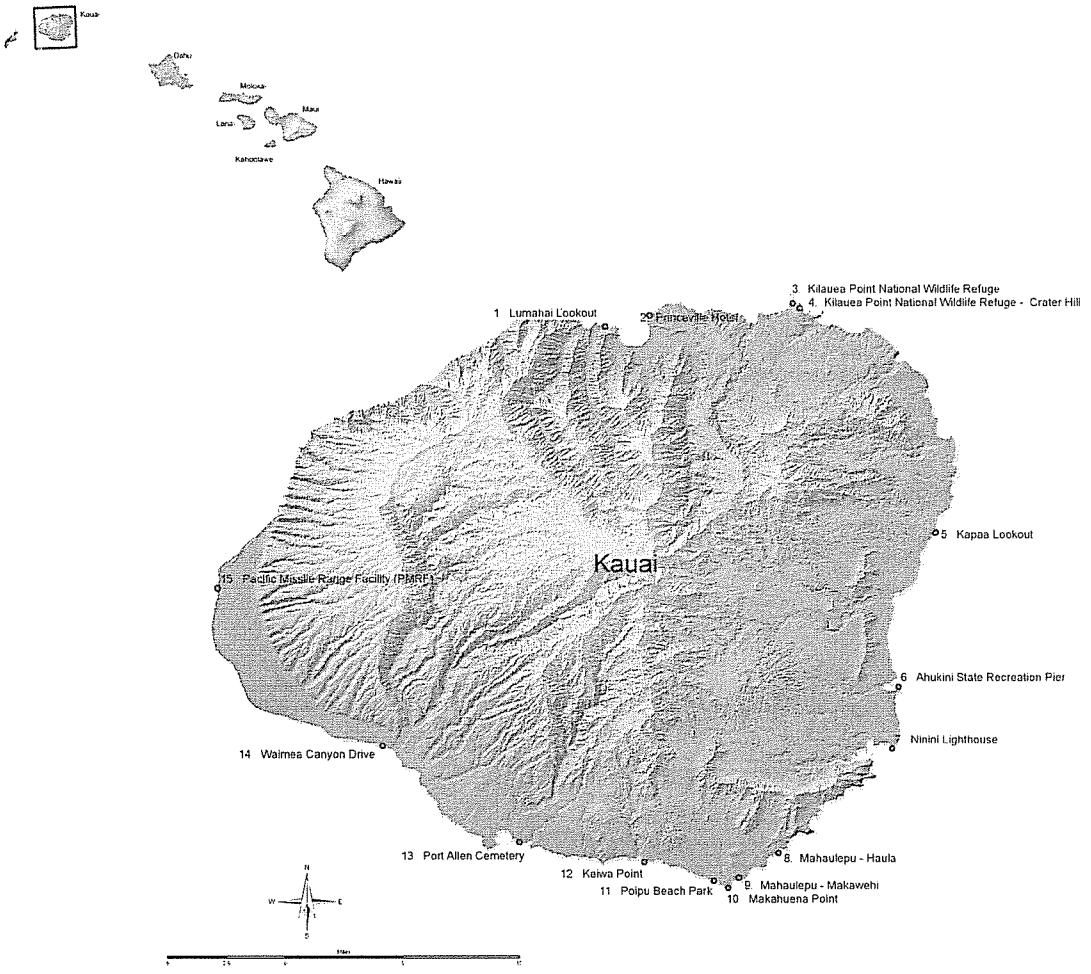

Figure 2 — Island of Kauai: location of the 16 shore-based sites where the humpback whale census was conducted between 2002 and 2005

METHODOLOGY

Censuses and behavioral sampling of humpback whales were conducted once a month during the last week of January, February, and March between 2002 and 2005. The census was performed by trained volunteers, many of whom participated for consecutive years. Two types of volunteers were trained: site leaders and regular volunteers. Site leaders were people willing to participate in mandatory training sessions to become able to coordinate, manage and train regular volunteers at assigned shore-based sites.

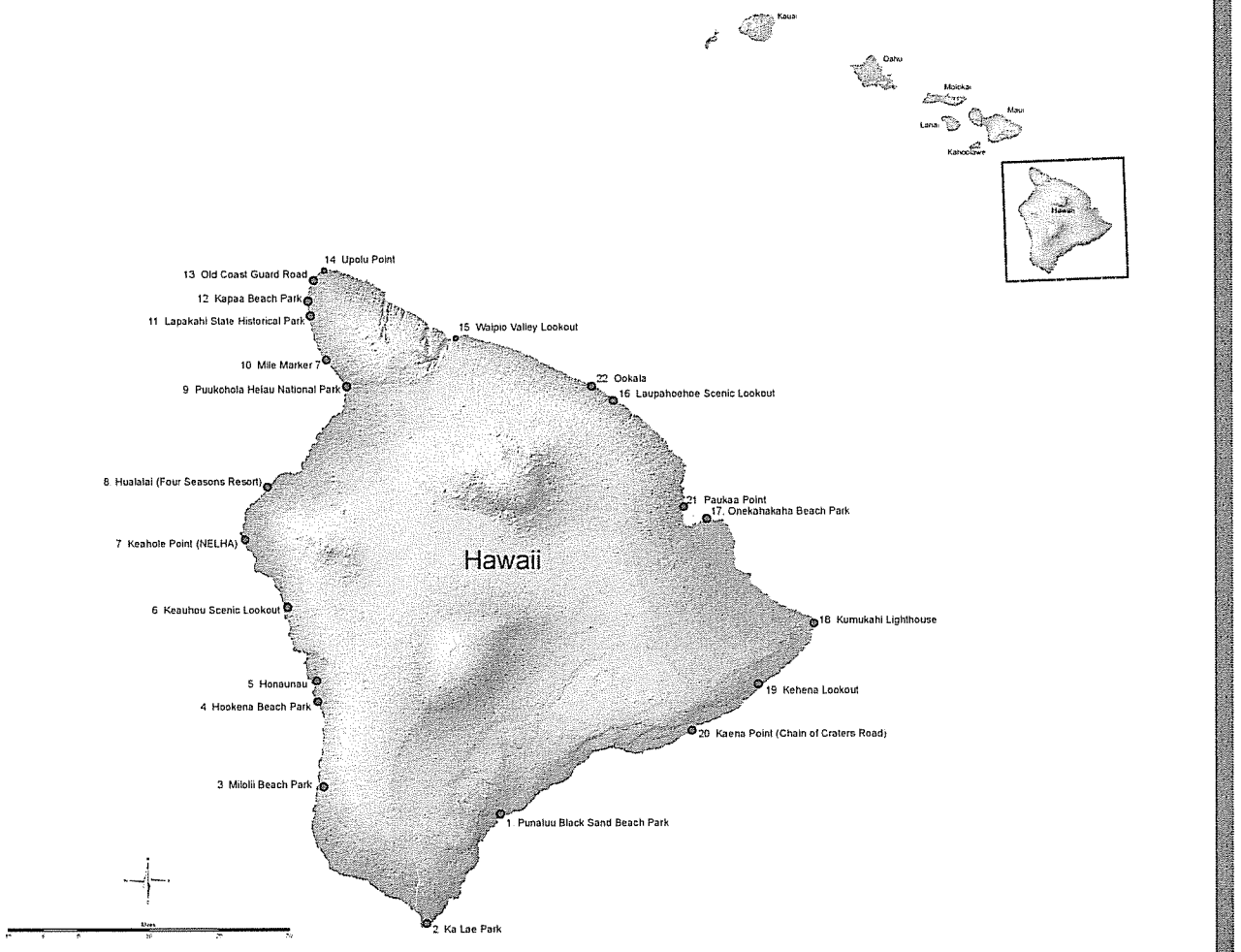

Figure 3 — Island of Hawaii: location of the 22 shore-based sites where the humpback whale census was conducted between 2002 and 2005

Regular volunteers did not have to undertake any formal training (except on Kauai where both site leaders and regular volunteers received the same mandatory training) and, after pre-registering, could show up at their chosen shore-based site on the day of the census to assist in data collection and whale observation. Site leaders were instructed to meet regular volunteers before 8:00 am at their assigned shore-based site on the day of the census and to conduct a brief training session on how to collect behavioral information. Site leaders reported preliminary census results immediately after the official closing of the census, at 12:15 pm, by calling sanctuary staff who remained available throughout the day to field questions and tally incoming census results. Site

leaders for a specific year generally remained the same for all count dates (Jan-Mar) on both Oahu and Hawaii. This was not the case on Kauai. Regular volunteers, generally, changed for each date on all islands. Census counts on Kahoolawe were conducted by volunteers from the Kahoolawe Island Reserve Commission (KIRC).

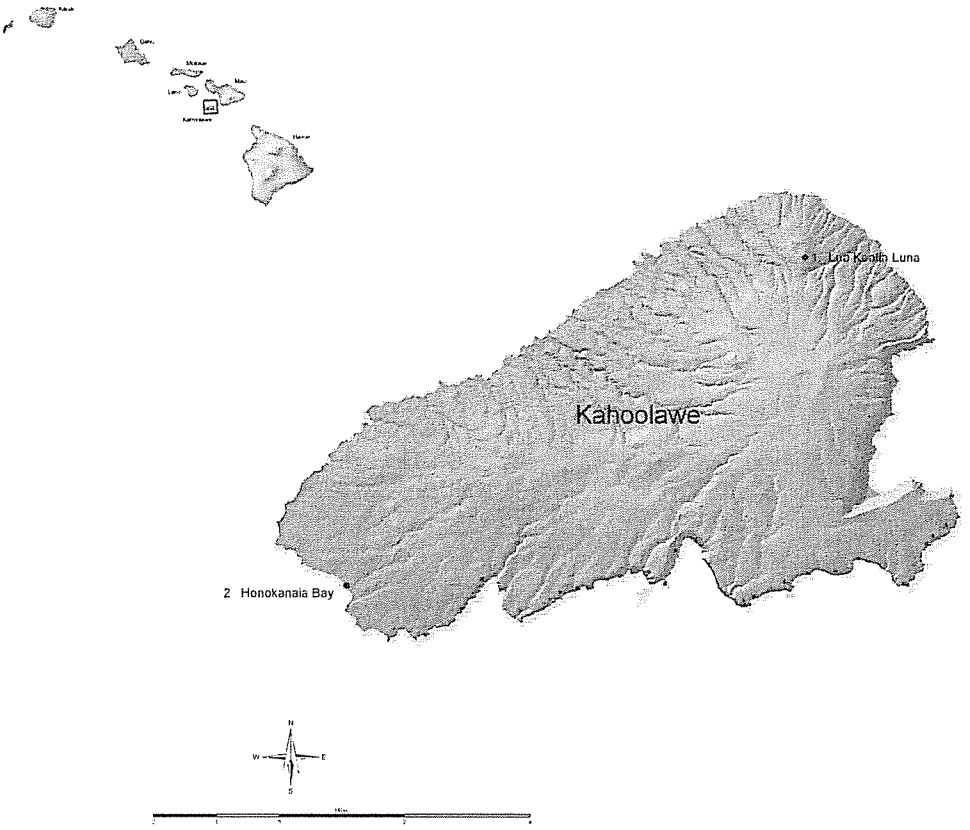

Figure 4 — Location of the one shore-based site where the humpback whale census was conducted between 2002 and 2005

Census Procedures

Census counts were completed by site leaders and behavioral observations by regular volunteers. Humpback whales were counted from fixed shore-based sites during nine 15-minute periods between 8:00 am and 12:15 pm. The waters extending 180° around land-based sites were scanned for the presence of humpback whales. When a whale was sighted, it was tallied and not re-counted during the same 15-minute period. Recorders

were asked not to count whales that surfaced before the start of the 15-minutes or immediately after even if they were aware of the whale's presence.

Behavioral Observations

Behavioral information was collected in a simplified manner to improve consistency among volunteers with different levels of experience. Volunteers were paired when possible. While one monitored the waters to observe whale behavior, the other filled out the data sheet. The tally of behavioral events was broken up into half-hour time slots between 8:00 am and 12:00 pm. The number of whales present at the site was estimated for each time slot so that number of behavioral events could be standardized against number of whales present for each time slot to get a relative index of behavioral activity that could be compared across sites.

Volunteers monitored all whales visible from their post and tallied any occurrence of breaching and slapping behavior. These two behaviors were selected because they are indicative of surface activity which in turn indicates social activity. It was assumed that areas where there is a consistently high frequency of surface active behaviors throughout the years are areas of importance to whales.

Although other behavioral categories were also recorded, these were deemed not useful to data analysis because the selected behaviors (number of blows and number of fluke-up dives) were often misinterpreted by volunteers and results were inconsistently tallied across years. In addition, these behaviors are not a useful indicator of importance of a particular area to the whales. For these reasons it is advisable that these behaviors are excluded from the data collection in the future.

Definitions of Behaviors

A 'breach' was defined as the act of jumping out of the water by the whale showing either its full body or only a portion of it, depending on the speed of exit from the water. A 'slap' was defined as the forceful beating of the water surface by the whale with any part of the body such as the flukes, the pectoral fins, or the rostrum.

RESULTS

Volunteer Participation

Volunteer participation (Table 1) fluctuated yearly but remained fairly consistent with an average of 900±61 on Oahu, an average of 106±53 on Kauai, an average of 443±85 on Hawaii, and an average of 6±7 on Kahoolawe. Bad weather affected participation in

some years (2004 in particular). Participation in Kahoolawe started in 2003 and was restricted since access to the island is by permission only. Volunteers from the Kahoolawe Island Reserve Commission (KIRC), the Island Marine Institute and the Maui Sanctuary Office participated at this site.

Island	2002	2003	2004	2005
Oahu	965	1003	728	905
Kauai	147	294	368	376
Hawaii	459	467	324	525
Kahoolawe	0	15	3	16

Table 1 — Number of volunteers that participated in the annual census between 2002 and 2005 on each island.

Census Results for Kahoolawe

Census counts on the island of Kahoolawe (Table 2) started in 2003. Most censuses were completed at the Lua Kelia Luna shore-based site (Figure 4), with the exception of March 2005 which was completed from Honokanaia Bay (Figure 4) because of weather.

Month	2002	2003	2004	2005
Jan	-	3 ± 3	7 ± 2	19 ± 5
Feb	-	12 ± 4	-	6 ± 3
Mar	-	4 ± 3	-	1 ± 1

Table 2 — Average number of humpback whales per 15-minute time slot (± Standard Deviation) counted from shore-based sites on the island of Kahoolawe between 2003 and 2005.

Because of the non-coordinated manner with which data were collected in Kahoolawe (i.e., different census dates and changing locations), and because the census started later than 2002, data for Kahoolawe were not included in the data analysis of all other islands.

Average number of whales per 15-minute time slot counted from a single shore-based site (Table 2) varied inconsistently yearly with February being the peak sighting month in 2003 and January being the peak in 2005.

Census Results on Oahu, Kauai and Hawaii

The average number of whales counted (Figure 5) was higher in January and February than March for all three islands suggesting whales leave all the study area at approximately the same time.

The average number of humpback whales counted per year on all islands and months combined (Figure 6) varied slightly between years with consistently lower numbers in March. Averages were similar among years but the overall number of whales was lower in 1994 and 1995. This may be due to the fact that bad weather affected the number of sites reporting in in 2004 and to a lesser extent in 2005. Whales may also have redistributed themselves around other islands that are not being sampled. It is therefore difficult to interpret this slight decline in number of whales.

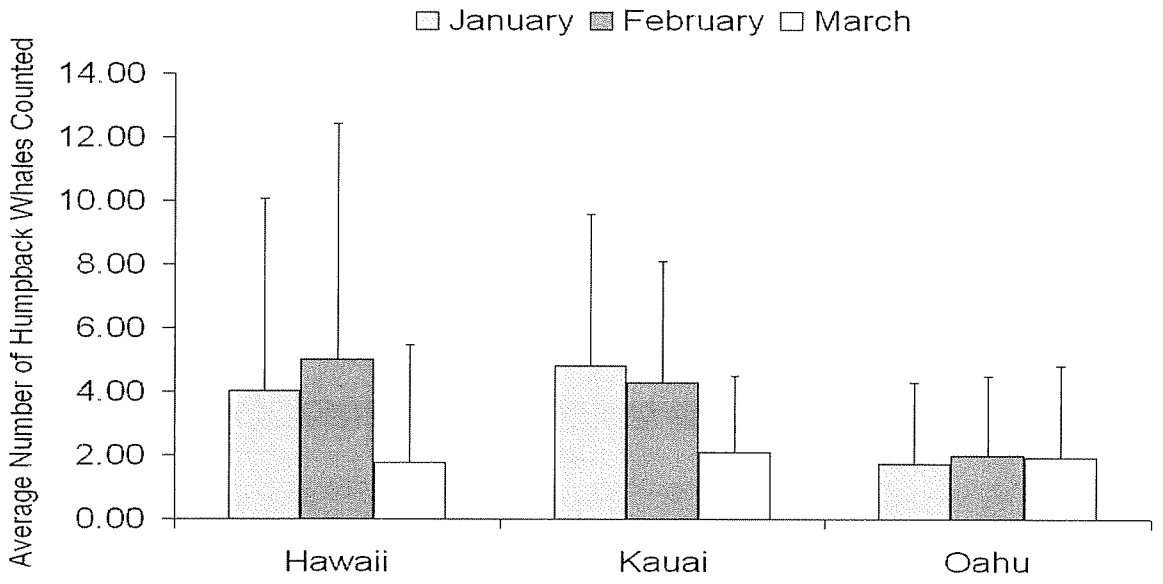

Figure 5 — Average number of humpback whales (± Standard Deviation) counted per shore-based site during the months of January, February, and March 2002-2005 around the islands of Oahu, Kauai and Hawaii.

There was no difference in average number of whales counted during the different time slots between 08:00 and 12:15 am. (Figure 7). This suggests that whales tend to remain near-shore during this time. It would be interesting to see if number of whales declined in the afternoon to determine whether inshore/offshore movement may occur later in the day.

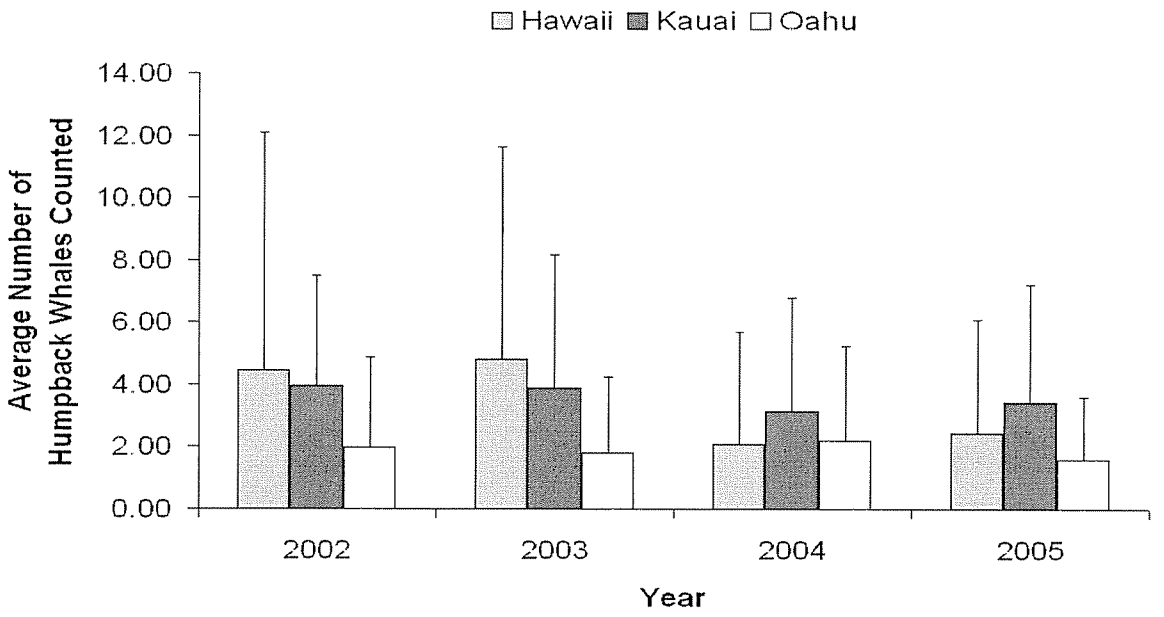

Figure 6—The average number of humpback whales (± Standard Deviation) counted per year between 2002 and 2005, during the months of January, February, and March combined, varied slightly between years with consistently lower numbers in March.

Behavioral Observations

An index was used to determine the frequency of 'surface active' behaviors for each shore site. Sites with a higher index relative to other sites had higher average incidence of 'surface active' behaviors indicating a potentially higher tendency for the site to be important for whales for mating, socializing or simply spending more prolonged periods of time.

The Surface Activity Index (indicating the average occurrence of 'surface active' behaviors was classified as Low if $0.38<x<0.46$, Medium if $0.47<x<1.48$ and High if $1.49<x<2.04$. This classification was developed by ranking all averages for all sites and determining the lowest and the highest average, and then, by dividing the range of values in four equal intervals.

Turtle Bay and Mokapu Point were the only two sites on Oahu where the Surface Activity Index was >1.00. On Kauai, Lumahai Lookout and Princeville Hotel were 0.95 and 0.80 respectively but no sites were above 1.00. On Hawaii, three sites were >1.00: Milolii Lookout, Upolu Point and Paukaa Point.

Results of the behavioral observations should be considered with caution. The relationship between 'surface active' behaviors and importance of the site to the whales In 2004, only the January count could be completed because of bad weather and the is

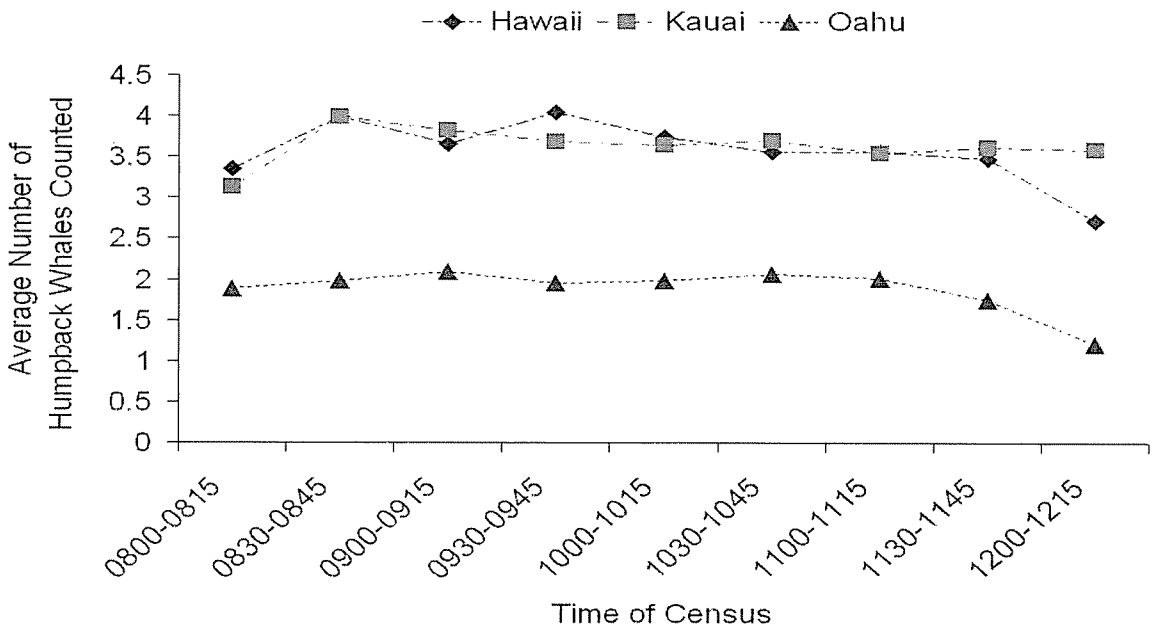

Figure 7—The average number of humpback whales (± Standard Deviation) counted per year between 2002 and 2005, during the months of January, February, and March combined, varied slightly between years with consistently lower numbers in March.

assumed and has not been demonstrated by hard data. Long-term observations at specific sites with data on age composition and group composition of whales present should be initiated to shed light on habitat use patterns. The sites where 'surface active' behaviors have been found, through these observations, to occur with high frequency, may be preferential sites for such a study.

Average number of whales sighted per shore-based site was calculated by averaging total counts at each site during each of the nine 15-minute time slots over all months and years to determine the probability of whales being seen at that particular site. The probability of spotting a whale was classified as Low if average number of whales per site for all years was $0.1<x<0.95$, Medium/Low if the average was $0.96<x<1.8$, Medium/High if it was $1.81<x<3.25$, and High if the average was $3.26<x<4.7$.

This classification was developed by ranking all averages for all sites and determining the lowest and the highest average for Oahu, and by dividing the range of values in four equal intervals. Oahu was used as the baseline. Anything above the highest average for Oahu (4.7) was considered very high. The reason Oahu was used as the meter for these values is that historically, number of whales around Kauai and Hawaii have been higher and probabilities for Oahu would have resulted artificially low.

The best three sites to spot whales on Oahu were Makapuu Point Lighthouse (x=4.67; SD=±3.76), Spitting Caves (x=4.00; SD=3.93) and Lanai Lookout (x=3.41; SD=2.84). On Kauai they were Mahaulepu Haula (x=7.33; SD=4.90), Kilauea Point NWR (x=5.08; SD=4.48) and Makahuena Point (x=4.75; SD=3.87). On Hawaii, the best three sites were Paukaa Point (x=12.25; SD=12.91), Upolu Point (x=11.33; SD=8.35) and Onekahakaha Beach Park (x=7.17; SD=10.87).

LITERATURE CITED

Craig, A. S. and Herman, L. M. (1997). Sex differences in site fidelity and migration of humpback whales (*Megaptera novaeangliae*) to the Hawaiian Islands. Canadian Journal of Zoology, 75, pp 1923-1933.

Herman, L.M. and R.C. Antinoja. (1977). Humpback whales in the Hawaiian breeding waters: population and breeding characteristics. Scientific Report of the Whales Research Institute 29: 59-85.

Maldini, D. (2003). Abundance and distribution patterns of Hawaiian odontocetes: focus on Oahu. Ph.D. Dissertation, University of Hawaii at Manoa. 125pp.

Mobley, J. R., G. B. Bauer, L.M. Herman. 1999. Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawai¢ i. Aquatic Mammals 25(2): 63-72.

Mobley, J., S. Spitz, R. Grotefendt. 2001. Abundance of Humpback Whales in Hawaiian Waters: Results of 1993-2000 Aerial Surveys. Hawaiian Islands Humpback Whale National Marine Sanctuary, Office of National Marine Sanctuaries, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Department of Land and Natural Resources, State of Hawaii: 1-16.